Clearwater Soil Monitoring

Soils Report

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for:
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Objectives

(1) Assess implementation of harvest for Abes Animals, Dog Marquette, Brick Trout and Beaver Triangle timber sales.

(2) Assess current conditions for soils on White White Project.

Introduction

A field survey assessed soil conditions after four timber sales were completed: Brick Trout, Abe's Animals, Dog-Marquette and Beaver-Triangle. The timber sales were completed within the last 3 years. In addition, the White White Project was field reviewed to supplement the environmental impact statement soils analysis. Field work was completed during July 8-11 and July 22-25, 2008. The timber sales were a broad example of timber harvest on the Clearwater NF. Harvest types were primarily clearcut with reserves, though occurred across different environments. Abe's Animals sale was on rolling palouse ground with deep soils. Topsoil has substantial ash accumulation and less than 10% rock. Brick Trout and Dog-Marquette were on steep slopes with moderately deep soils, <40 inch depth, some surface rock (10-35%) and a moderate ash layer (4-12"). Beaver-Triangle was a high altitude site on the Powell district on raw granitic soils with thin, mixed ash topsoil.

Methods

Soil condition was reviewed using R1 protocol (in review), soil groundcover frequency transects, and coarse wood assessments (Lutes 2003, see Fire.org). The R1 protocol classifies soil disturbance according to Regional Soil Guidelines of detrimental soil disturbance (USDA 1999). Detrimental disturbance occurs where impacts lead to long term reductions in soil productivity. Thresholds are defined in the Regional Guidelines for damage to porosity from compaction, displacement, erosion and severe burning (1999). Burn severity is further defined in Debano et al (1998). Soil condition was assessed by classifying soil disturbance along randomly placed

transects. Points at 50 foot intervals were described for soil disturbance using the R1 protocol. Each unit was completely traversed to ensure accuracy. Assessments were done by USDA soil scientists Vince Archer and Dustin Walters.

Coarse wood and ground cover estimates were calculated using 50 foot transects and point estimates. At every point along the soil condition transects, ground cover including wood was catalogued. In addition, at least three to four 50 foot transects were used to assess coarse wood debris and forest floor duff and litter depths. Results were tabulated in tons/acre for coarse wood and centimeters for forest floor depth. Ground cover was estimated using the same 50 foot (10 pace) spacing used to describe soil disturbance. However, some burned units in Brick Trout were described using one foot spacing since the ground cover was highly variable. Ground cover data was summarized as percent total for basal vegetation, bare ground, duff/litter, rock, wood and moss.

The timber sales monitored include: Abe's Animals, Palouse District, five miles north of Boville (T41N, R1W, Sec 12, 13); Dog-Marquette Sale, North Fork Clearwater District, 5 miles NW of Canyon Work Center (T41N, R6E, Sec 24), Brick-Trout Sale, Lochsa District, 20 miles E of Kamiah (T 34N, R6E, Sec 27, 28, 33, 34); White-White Project, Lochsa District, 25 miles NE of Kamiah (T35N, R6E, Sec 28, 33); and Beaver-Triangle Sale, Powell District,10 miles east of Powell (T9N, R15E, Sec 13, 21-23).

All sales except for the White White project were recently harvested. Monitoring on White White focused on describing existing conditions prior to timber harvest. All recent harvest was clearcut with reserves with the exception of Abe's Animals; Abe's Animals was a commercial thin. The clearcut with reserves had many mature trees that averaged 20 trees/acre in a mosaic. Drainage features generally had more trees. Slash treatment included pile burning versus prescribed burning. Brick Trout and Dog-Marquette had follow-up prescribed burning (see Table 1). Abe's Animals used excavator pile burning dispersed for units 9a, 9b, and 10, in addition to trails only piling for units 13, 14, 16, and 17. Beaver-Triangle sale has prescribed burn planned, though had only burned 10% of skyline unit 2.

Logging systems across the sales were a mix of skyline, cable and tractor. The best contrast in ground based logging systems were Abe's Animals and Beaver-Triangle. Abe's used a cut-to-length system that is in-woods processing, leaving slash in situ and enabling a slash mat. Beaver-Triangle used a feller buncher and rubber tired skidder, considered a whole tree harvest system, where all material is hauled to a central landing for processing. Brick Trout and Dog-Marquette had larger diameter trees and thereby used hand-falling with skidding and skyline cable.

Soils were similar for Dog-Marquette, White White and Brick Trout (see Table 2, Appendix 2). Dog-Marquette is perched on the top of rounded ridges that abut the sharp dissected valley of the North Fork Clearwater. White-white and Brick Trout are situated in the classic rolling hills country that borders the basalts (Appendix 2). The terrain is steep and has very high variability in regards to soil depth depending on aspect and ash accumulation, but slopes lack the extended lengths found in the North Fork country. Soils within these projects generally consisted of ash of 4 to 12 inches over schistose, grano-diorite parent rock on dissected slopes and ridges. These soils were shallow to moderately deep. An exception was a sandy soil on a flat ridge for units 47 and 27. Habitats were similar for all three projects with western red cedar/Oregon boxleaf (USDA 1983).

The strongest differences in soils were found on the dissected slopes and changes to bedrock within projects. Ridge soils and backslopes had parent bedrock close to the surface with very thin

soils amongst rock outcrop. Barren cutslopes were a strong indication of droughty thin soils along warm aspects and where bedrock was close to the surface. Comparatively, moist and cool aspects had thick vegetation along cutslopes that correlated to higher ash accumulation and deeper soils. In Brick Trout, the schistose slopes seemed to have good regeneration within 1980's clearcuts compared to the grussy granitics near trout creek. Regeneration here was considerably less with bare soil common throughout. White-white showed less subwatershed differences, but with stronger slope dissection and therefore higher variability within units. Tight drainages had deep alluvial soils that were susceptible to compaction compared to thin, rocky robust ridge soils that seemed impervious to impacts from tractor skidding. Dog-marquette had similarly contrasting soils where rocky complex ridge terrain.

Soils on Abe's Animals were deep ash on residuum. Ash is 10 to 20 inches thick and creates silt loam textured topsoil (also see Appendix 2). Soils are moderately developed inceptisols on moderate relief uplands and develop clay accumulation on the alluvial parent materials in the flat lying, low relief areas. Soils formed on rolling hills that have influence from primarily ancient alluvium deposits out of Palouse loess and decomposed basalts along with secondary influence from Idaho batholith granitics (USDA 1983). Soils are unmatched compared to the other projects with the highest site productivity. Habitat type is western red cedar/Oregon boxleaf (1983).

Beaver Triangle is a moderately high elevation area with thin ash on raw granitic soils near the Bitterroot divide. Soils were shallow to moderately deep, skeletal, and had mixed ash. Ash was generally less than 10 inches deep. This location was unique with primarily frost churned ridges of the Idaho batholith, with some minor till pockets (USDA 1983). Slopes were broad and lacked dissection as with all the other projects monitored. This project area likely had some of the least soil variability. Habitat was alpine fir/menziesia and alpine fir/beargrass (1983).

Table 1. Site conditions for timber sales monitored.

Timber Sale	Acres	Elevation	Dominant Soil Type	Harvest Type	Fuels Treatment
Beaver Triangle	129	6000-6400'	Andic cryochrepts, loamy-skeletal, mixed	Fellerbuncher-skidder/ Skyline	Rx Burn (Not done)
Brick Trout	222	3400-4400'	Andic Dystrochrepts, loamy-skeletal, mixed frigid	Tractor/ Skyline	Rx Burn
Dog Marquette	88	4200-4300'	Andic Dystrochrepts, loamy-skeletal, mixed frigid	Tractor/ Skyline	Rx Burn
Abe's Animals	143	2900-3000'	Andeptic Paleboralfs, Typic Vitrandepts, medial/loamy, mixed, frigid,	Cut-to-length	Excavator Pile/burn
White White	203	3400-4000'	Andic Dystrochrepts, loamy-skeletal, mixed, frigid Typic Vitrandepts, medial/loamy, mixed, frigid	Tractor/ Skyline	Rx Burn

Post Harvest Monitoring Results and Discussion:

Soil condition following timber harvest depended on the harvest system and fuels treatment used. Skyline yarding resulted in the least detrimental soil disturbance compared to tractor systems. For tractor yarded units, soil moisture, the type of fuel treatment, and operator efficacy were the

biggest factors in soil disturbance. Skyline harvest led to 0 to 7% detrimental soil with most of the disturbance from severe burning following harvest. Tractor harvest led to 8 to 22% detrimental disturbance after harvest. Fuels treatment disturbance was from excavator piling and follow-up burning. This disturbance was particularly noticeable in Abe's Animals where the excavator piling was not limited to skid trails. All Dog-Marquette units and some of the recently burned Brick Trout units had very good mosaic burn patterns. Initial burns in the Brick Trout units done in 2005 had moderate to high burn severity. The higher burn severity hinders recovery for roughly a decade compared to the mosaic burn pattern based on observations from Forest Staff. Recent burning in the Brick Trout units achieved low to moderate severity conditions more like the Dog Marquette burning.

Harvest System Results

The skyline harvest systems had low disturbance values despite the large material logged. These systems typically had higher disturbance from follow-up prescribed burning. In contrast, the ground-based systems had very high disturbance from cut-to-length in-woods harvesting, feller-buncher/skidder systems and hand-felling/skidding systems. The only ground cable portion of a unit had similar results to skyline areas with no detectible detrimental disturbance.

The skyline units averaged 3% (+/- 1) detrimental disturbance from temporary road building and follow-up burning. The greatest contrast in burning was between the Dog-Marquette and Brick Trout sales (see Figures 2 & 3). Bare soil and forest floor depths varied widely depending on forest type and burn severity.

Table 2. Detrimental disturbance percent summary statistics by logging system.

Detrimental Disturbance (%)				
	Ave	**SE**	**Range**	**Count**
Tractor (all)	14	+/-1	7-22	13
Feller Buncher	13	+/-2	8-20	6
Cut-to-Length	14	+/-2	7-18	5
Handfall/skidder	18	+/-3	15-22	2
Cable	0	-	-	1
Skyline	3	+/-1	0-7	11

The results from tractor harvest have a wide range, from 7 to 22% detrimental disturbance. All timber harvest was done during summer and not mitigated by frozen or snow covered ground. No consistent trends were found when comparing the different types of ground-based systems. Table 2 lists the summary statistics from the survey.

Feller buncher systems led to 8 to 20% detrimental disturbance, averaging 13% (+/-2). All units using feller bunchers operated on soils with coarse rock near the surface and moderately even slope shapes. Operational conditions that led to higher disturbance were dispersed skidding traffic and small unit sizes. Units 3 and 4 had 8% and 15% detrimental disturbance respectively. Designating skidtrails at 50 to 70 feet lowered soil and using sufficient non-merchantable slash lowered machine impacts to soils. Units 5 and 6 had soil disturbance at 17% and 20% where skidtrails were either dispersed or less than 50 feet spacing. However, these units were also small at around 10 acres.

The in-woods processing, cut-to-length harvest, ranged from 7 to 18% detrimental disturbance with an average of 14% (+/-2). A slash mat effectively reduced soil displacement for most of the harvest units except where wet conditions prevailed (Figure 1). The harvest area had deep ash soils with low bearing capacity from lack of surface rock and therefore were highly susceptible to compaction and displacement. Units 9a, 9b, and 10 were over the 15% threshold for detrimental disturbance from follow-up pile and burning. Detrimental disturbance was 16% to 17% in these units. Unit 14 had 18% detrimental disturbance prior to fuel treatment from extensive rutting (see Figure 1).

Hand felling with rubber tired skidding was used on Brick Trout and Dog Marquette sales. The results from this system were limited since only two units had primarily tractor harvest, units 1 and 4 on Dog Marquette. Detrimental disturbance was related to timber harvest impacts. Topography restricted travel and yarding large diameter cedar logs displaced soil. Skidtrail designation was adequate with at least 60 feet between trails.

The disturbance that results from ground-based units corresponds are within range of values reported on neighboring forests. Jerry Niehoff's data for the Idaho Panhandle NF found mixed cut-to-length and feller buncher harvest systems averaged 13% detrimental disturbance for the Idaho Panhandle and skyline resulted in 0% detrimental disturbance (Niehoff 2002). We reviewed four sales on the Lolo NF and found ground based systems, predominantly feller buncher, resulted in a higher range and similar average. Results on the Lolo NF showed ground based harvest with either excavator pile burning or prescribed burning led to 7 to 41% detrimental disturbance (Vander Meer and Archer 2007). Ten of the 25 ground based units were under the 15% threshold. Skyline harvest with follow-up burning led to 2 to 4% detrimental disturbance (2007).

Clayton (1990) reports higher soil disturbance values than found during the Clearwater NF monitoring, possibly from the lack of best management practices at the time. Clayton (1990) found soil disturbance at 9% for skyline, 23% for ground-cable, and 30% for tractor logging. Monitoring on the Nez Perce NF of two units on the Mackey Day Sale found very high values despite using a slash mat, mostly related to widespread equipment use and follow-up excavator piling and burning (Green 2003).

Fuel Treatment Results

Fuel treatment of slash affected long term recovery, though with varying impacts according to method and prescribed burning outcome. The Palouse District had impacts from the excavator pile and burning that resulted in up to 4% detrimental disturbance (Table 3). The Dog Marquette timber sale had mosaic prescribed burning leaving a good mix of burned and unburned understory vegetation that broke up fuels continuity. Results were at most 2% detrimental disturbance. Brick Trout Sale had variable results for prescribed burning with some units burned cool with native understory retained versus some very hot burns that resulted in near complete Canada thistle growth. Detrimental disturbance from this burning were low (<2%) given the regrowth, albeit weedy. Beaver-triangle Sale had only one unit partially burned resulting in 6% detrimental disturbance. The partial burning did not appear to have the same mosaic pattern as Dog Marquette, although this was concentrated within the accumulated slash of at the upper end of skyline yarded unit 2.

The impacts of excavator pile burning is best compared using the Abe's Animals sale. Units 9a and 9b had excavator travel across the unit, leaving coarse wood levels between 2 and 13 tons/acre. Comparatively, using Graham et al (1994) recommendations, coarse wood is from 16

to 32 tons/acre for western hemlock areas, possibly more mesic than this location. However, the 2 to 13 tons/acre seems beyond the natural range given the potential habitat for western red cedar.

For units 9a/9b, detrimental disturbance from severe burning amounted to 3%. Unit 10 also had dispersed excavator use to pile and burn, with more frequent piling; severe burn from burn piles amounted to 4% detrimental disturbance. The burn scars on unit 10 were dense with pile spacing every 100 to 150 feet. Limited excavator use on these units would likely have resulted in lower amounts of disturbance with greater spacing of burn piles and less disturbance across the unit. It is important to note that the percentages attributed to the pile burning only account for severe burning and do not include impacts from excavator travel. This disturbance overlaps harvest disturbance and is near impossible to separate.

Units 13/17, 14 and 16 were sampled to compare effects since these areas had not yet been piled and burned. These units have a different piling contract and are limiting piling to existing skid trails. These conditions may have less impact on soils since disturbance will be limited, not dispersed, and a different operator may improve performance.

Detrimental disturbance comparisons did not illustrate clear differences since wet soils in units 14 and 16 led to rutting. However, the coarse wood levels measured in these units were within Graham's (1994) guidelines for the habitat. At least from a coarse wood perspective, further piling may not be needed. Coarse wood was from 4 to 20 tons/acre (see Appendix 1), discontinuous and within 12 inch height. These levels are within the recommended balance for soil productivity and lower fuel risk (Brown et al 2003).

Results of prescribed burning were highly variable and depended on soil moisture, slope steepness and fuel bed. Prescribed burning can benefit soil productivity with elevated mineral N in the first two years and beneficial attributes from carbon (see Erickson and White 2008). Where prescribed burning is severe, infiltration can be impaired along with erosion of topsoil (Grier et al 1989). Severe burn impacts were limited, even in the very hot burn units within Brick Trout. However, the burning led to very different outcomes for biologic elements such as forest floor, soil groundcover, coarse wood and forest understory regrowth. Using these parameters, the burn impacts were rated as "good", "fair" and "poor" (see Table 3 and Appendix 1) to better contrast the effects from the burning. These ratings focus on the retention of organic matter as a performance measure since organic matter is directly tied to nutrient base, soil protection, and biologic function.

Table 3. Detrimental disturbance attributed to severe burning.

Project Unit	Logging System	Fuels Treatment - Rating	Harvest Dist. (%)	Fuels Dist. (%)	Bare Soil %
BT* 2 (Sale)	Skyline/Tractor	Rx Burn - Fair	2	2	24
BT 3	Skyline	Rx Burn - Excellent	0	0	13
BT 4	Skyline/Tractor	Rx Burn - Poor	7	0	33
BT 5	Skyline	Rx Burn - Fair	5	3	22
BT 6	Skyline	Rx Burn - Good	3	0	10
BT 7	Skyline	Rx Burn - Good	7	0	20

Abe 9a/9b (Sale)	Cut to Length	Excavator pile/burn	16	3	8
Abe 10	Cut to Length	Excavator pile/burn	17	4	16
Dog 1 (Sale)	Tractor/Cable	Rx Burn - Excellent	22	0	20
Dog 2	Skyline	Rx Burn - Excellent	0	0	13
Dog 3	Skyline	Rx Burn - Excellent	2	2	27
Dog 4	Skyline/Tractor	Rx Burn - Excellent	16	2	26
B-Tri 2	Skyline	Rx Burn (10% of unit)	6	6	6

*BT= Brick Trout, Abe= Abe's Animals, Dog= Dog-Marquette, and B-Tri= Beaver Triangle

If these ratings are used in the future, note that they are a subjective aid and should be modified to account for different habitats as additional research becomes available. Fire severity terminology was not used since the term is often confused with fire intensity and interpretations vary (see Jain et al 2006). The ratings are listed below:

"Good" - Burn achieves a mosaic pattern. This rating was assigned where forest understory was partially consumed, full consumption (all black) limited to less than 30% across the unit. Jackpot burn areas were few and not contiguous. Forest floor averages at least 1 to 2 cm across the unit. Bare soil is less than 20%. Coarse wood is 50% to 80% of preburn levels.

"Fair" – Forest understory fully consumed for 30 to 60% of the unit area. Jackpot burn areas were common, but not contiguous. Forest floor averages at least 1 to 2 cm across the unit. Bare soil is less than 30%. Coarse wood is 10-50% of preburn levels.

"Poor"- Forest understory remains on less than 10% of unit. Burn area is black across most of the unit. Forest floor less than 1 cm across the unit. Bare soil greater than 30%. Coarse wood is less than 10% of preburn levels.

Prescribed burning of the Dog-Marquette units is a great example for mosaic burning with a mix of unburned and burned areas (see Figure 2). Units 1,2 and 4 had "good" ratings with unit 3 having a "fair" rating with bare soil 27%. Burned areas have limited bare area reducing soil erosion potential and promoting continued soil biologic function. In addition, understory re-growth in all units was very robust with primarily native species.

Brick Trout burning produced mixed results (see Figure 3). Unit 4 had dry burn conditions coupled with coarse wood levels in excess of 80 tons/acre. In particular, this fuel bed had abundant 100 hour fuels of cedar and grand fir growth that burn very hot. These conditions led to a hot burn that consumed all the forest floor and native understory vegetation. Regrowth is predominantly Canada thistle (see unit 4 in Figure 3) and bare soil from 10-30%, almost all due to followup burning. More recent burning in the Brick Trout project shows considerable improvement with similar results to Dog-Marquette. The forest floor is preserved and a much higher proportion of coarse wood exists and understory vegetation is abundant (see unit 3 in Figure 3 and units 3 and 6 in Table 3).

For Brick Trout, the detrimental disturbance percentages are low compared to the ecological effect. Initially after burning, the survey would have resulted in much higher disturbance ratings with signs of severe burn such as white ash and discolored soils. At the time of survey, at least two growing seasons had passed thereby masking the indicators of severe burning. Detrimental disturbance mainly represents timber harvest disturbance.

Prescribed burning in Beaver-Triangle was not completed and therefore these units were not rated. Unit 2 has 6% detrimental disturbance from burning despite only 10% completion at the time of survey. The high percentage is from the severe burning in concentrated fuels at the top of this skyline yarded unit.

Biologic Resiliency

The Clearwater NF ensures soil protection and long term site productivity with Forest-wide standards and through implementation of Regional Soil Guidelines (USDA 1999). Long term productivity is traditionally assessed using disturbance thresholds. However, soil science has increasingly focused on organic attributes associated with nutrient cycling, plant and microbial associations, and physical and biological benefits of forest structure such as downed wood. Forest structural elements such as the forest floor and woody residues, in particular, lignified soil wood, have gained increasing attention in regards to soil management (Harvey et al 1987, Graham et al 1994, Brown et al 2003, Brais et al 2005, Page-Dumroese et al. in review). Therefore, the impacts of management actions can also be considered using biologic resiliency as a framework to ensure long term soil productivity goals (Perry and Amaranthus 1997).

All these biological elements are susceptible to timber/fire management induced degradation. Forest floor litter and duff can be compromised by loss from fire or an imbalance between annual litter contribution rates and decomposition rates, common in units where most of the trees are removed. Lignified soil wood is lost through severe burning and lack of large wood contributions. Lignified soil wood is typically associated with old downed dead logs with brown cubicle rot. The importance of this material is not so much as nutrient capitol, but as physical amendment –a microsite- that moderates soil moisture for microbial activity (see Harvey et al 1987, Laiho and Prescott 1999, Pyle and Brown 2002).

For example, results of the burning in unit 4 on Brick Trout led to 30% bare soil, removed the forest floor, and reduced coarse wood from 80 tons/acre to 7 tons/acre. The loss of forest floor and reduced coarse wood will have slower recovery than the very highly disturbed ground based unit 14 in Abe's Animals and unit 1 in Dog Marquette sale where all biologic elements are conserved. Detrimental disturbance in the Brick Trout unit was assessed at 7% compared to 18% and 22% in Abe's Animals and Dog Marquette respectively. The Brick Trout unit 4 burning did not have overt signs of severe burn, thus most of the unit was not assessed as detrimental. Coarse wood for Dog Marquette unit 1 was from 0-65 tons/acre with large logs present and 5 to 20 tons/acre in Abe's Animals unit 14. Forest floor with both litter and duff elements and understory forest vegetation species were retained. Another indicator, bare soil, was 30% in the Brick Trout unit compared to 20% in Dog Marquette and 3% in Abe's Animals.

The understory growth patterns between these units also contrast biologic potential. The Brick Trout unit 4 has 90% Canada thistle compared to intact native understory in the ground based units. The presence of exotic, weedy plants can affect nutrient cycling and impede native plant recolonization (see Callaway et al 2004, Thorpe and Callaway 2006). In contrast, the ground based units where rutting and compaction were prevalent have complete forest understories and relatively small proportions of exotic weeds. This native understory coupled with a forest floor

and adequate downed wood stores have high biologic resiliency and therefore faster recovery potential.

Biologic resiliency is also assessed in the context of soil type. For the Brick Trout sale, the sandy loam schist and granitic soils have very little buffer once disturbed, especially on south slopes where the ashcap is thin and moisture limiting. 1980's era clearcuts showed clear differences in recovery on north versus south aspects within the Brick Trout project area. This area has stand-replacing fire disturbance regime, though on a century to two century timescale. Management impacts are increasingly turning to repeated entries with impacts on a decadal scale. Therefore, though these habitats have good moisture regimes and are adapted to large-scale disturbance, biologic elements become important to sustain productivity in the smaller timescales of management framework (also see Grier et al 1989, Jurgenson et al 1997).

In contrast, the deep palouse soils of the Abe's Animals sale have good moisture in addition to deep nutrient rich soils. Forestry is intermixed with farmland applications in this area. Page-Dumroese and Jurgenson's (2006) inventory of habitats provides a good baseline reference for organic matter structure and carbon and nitrogen contents that complements the Clearwater NF's land system inventory (USDA 1983). Using these sources, biologic resiliency can be assessed using the distribution of organic matter. Habitats with most of the organic matter towards the surface will have proportionally higher losses and less recovery potential if the forest floor is removed and only low amounts of coarse wood are left.

Recommendations:

- Monitor soil moisture to lessen rutting- limit to less than 25% moisture. Impacts do vary according to soil texture, though 25% represents a conservative threshold where visual indicators such as clumped soil and surface sheen become apparent.

- Limit excavator piling to skidtrails. Originally proposed by Froehlich and McNabb (1983) for limiting compaction, this practice holds true despite lower pressure equipment. The dynamic pressure of loaded vehicles compacts soils. Tracked vehicles displace soil from turning.

- Use a slash mat. Use of slashmat may not eliminate compaction, but does provide biological substrate for faster recovery. Slashmat effectiveness was found to deteriorate after 3 to 4 trips (Han et al 2006).

- Minimize equipment traffic with designated skidtrails, though narrower spacing may be okay. Monitoring on the Lolo NF found lower disturbance for 50 foot skidtrails where using a feller buncher with less off trail traffic and less disturbance between tracks and a higher frequency of skidtrails (Vander Meer and Archer 2007).

- Burn towards a mosaic rather than broadcast. The Idaho Panhandle NF uses a lower threshold of 25% soil moisture for burning. Consumption of wood residue decreased two to three fold when burning when soil moisture averaged 30% (Page-Dumroese et al In review) and Niehoff (2002) reported detrimental disturbance from broadcast burning decreased from 30% to 0%. Tradeoffs are deeper penetration of lethal heat from steam that results from burning

moist soil (Dunn et al 1985). Also, spring burning can adversely affect spring growth of plants since burning occurs when plants are actively growing (Hart et al 2005).

Pre-Harvest Monitoring Results and Discussion

The project proposes primarily clearcut harvest with reserves, similar to prescriptions on the Brick Trout sale. Units 27 and 47 would be commercial thinned. Harvest log systems would be a combination of tractor and skyline.

The project area soils are primarily silt-loam ash on skeletal, sandy loam soils derived from grano-diorite residuum/colluvium. The landforms are highly dissected with boulder outcrop on ridges. Ash is moderately deep, 6 to 12 inches, on protected aspects. The loam to sandy loam subsoils are finer than expected probably from ash influences. Soils are mostly moderately deep and well drained. Soils for units 27 and 47 lack rock substrate and thus have lower bearing strength against machine impacts.

The topography is the largest concern using ground based equipment for tree felling. Many of the units planned for tractor have very steep pitches where harvest equipment could displace and compact soil. However, most of these units have a mix of tractor and skyline. Unit 4, listed for tractor and skyline, has high risk for soil disturbance since slopes are from 40-70% except for the temporary road planned along the ridge. Tractor harvest opportunity would be minimal if slope restrictions are met for <40%.

Seeps were found in unit 1 and the timber marking showed adequate protection. Overall, timber marking excluded harvest in steep concavities and avoided areas where soil surface stability was questionable. No large scale mass failure sites were identified.

Soil disturbance from past harvest was evident in all the units, though the impacts were moderate at less than 5% detrimental disturbance. Four of the 12 units surveyed had current conditions that will have potential adverse cumulative effects; units 3, 5, 6, and 10. Soil disturbance in these units were greater than 7%. Coarse wood levels and groundcover measures all showed adequate conditions, even in the units with the most extensive past logging.

Soil disturbance was primarily from partial harvest in the early 1980's along with older select tree logging (big old rotten stumps). Units 27, 28 and 47 had soil disturbance of unknown origin. The select cutting was light except for a portion of unit 3, and within units 5, 6 and 10. Past timber harvest disturbance was from log skidding along ridges and up drainages and side-channels. Benched sidecuts and recent temporary road building was evident in units 3, 4, 7 and 9. Steep slopes generally had low disturbance since logs were cable yarded, although steep pitched ridges in unit 3 had signs of tractor yarding. Benched roads were found in units 4, 7 and 9 on steep slopes where regeneration of grand fir is thick, almost impassable. Table 4 shows the current condition in the units using numbering from the Environmental Assessment. Soil condition transects found past disturbance resulted in primarily 3 to11% detrimental disturbance. Units 2, 4 and 1 had very minor disturbance from past harvest. The tractor portion in Unit 3 had very high disturbance from a dense network of skidding on flat ground. Detrimental soil disturbance was 18% of this tractor portion.

Table 4. Summary data from soil condition survey within White White Project. All units planned for clearcut with reserves except for commercial thinning in units 27 and 47. Unit numbering uses the Environmental Assessment nomenclature. Soil disturbance is detrimental soil disturbance as defined in the Regional Soil Guidelines (USDA 1999).

Unit	Acres	Logging System	Slope	Aspect	Soil Dist (%)	Forest Floor* (cm)	CWD t/a	Temp Roads (%)
1	52	Skyline /Tractor	20-40%	W	2	7	3-10	
2	22	Skyline /Tractor	0-40%	W	4	5	8-12	
3	20	Tractor portion	0-40%	SW-W	18	5	7-22	2
3	23	Skyline portion	30-50%	S-SW	3	3	5-18	
4	17	Skyline /Tractor Swing	40-70%	W	4	4	5-25	1
5	13	Skyline /Tractor	5-40%	W	10	2	7-18	
6	8	Skyline /Tractor	5-40%	W	10	2	7-18	
7	17	Tractor	5-50%	W	7	7	8-16	1
9	20	Skyline /Tractor	10-50%	W	3	5	5-15	1
10	6	Tractor /Skyline	5-35%	S-W	11	5	5-15	
27	4	Tractor	5-35%	W	0	5	6-14	
28	2	Tractor	10-35%	W	0	4	10-20	
47	9	Tractor	10-20%	W	5	6	4-25	

Abe's Animals:

Figure 1. Cut to length harvesting on slashmat in unit 13 and unit 16. The rutting was isolated to unit 16.

Dog-Marquette Sale:

Figure 2. Looking south at unit 4. Treatment is clearcut with reserves using hand felling, tractor skidding and follow-up prescribed burning.

Brick Trout:

Figure 3. Brick Trout Sale with contrasting high severity prescribed burn in unit 4 versus low severity mosaic prescribed burn in unit 3. Both units were harvested using predominantly skyline yarding and have the same clearcut with reserves treatments.

White-White:

Figure 4. Example of target forest for fuels reduction.

Beaver-Triangle:

Figure 5. Contrast of skyline (above) and ground based logging systems (below) using feller buncher whole tree yarding.

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Appendix 1. Summarized field data.

Table 1. Monitoring results for post harvest units.

Project	Unit	Rx	Acres	Log System	Fuels Treatmt	Slope	Aspect	Bare Soil %	Forest Floor (cm)	CWD (t/a)	Soil Disturb %	Factors why >15%
Abes Animals	17/ 13	Com Thin	50	Cut to Length	Excavator pile/burn	10-35%	S-E	2	4.7 L/D	4-20	7	-
Abes Animals	16	Com Thin	8	Cut to Length	None	0-35%	S-E	0	2.8 L/D	5-11	12	Wet soils, confined skidtrails, past impacts
Abes Animals	9a/9b (Sale)	Com Thin?	39	Cut to Length	Excavator pile/burn	10-30%	S	8	1.5 L/D	2-13	16	Slash piling not limited to skidtrails
Abes Animals	10	Com Thin	16	Cut to Length	Excavator pile/burn	10-30%	SE	16	1 L/D	0-10	17	Extensive slash pile/burning
Abes Animals	14	Com Thin	30	Cut to Length	None	0-35%	S-E	3	1.9 L/D	5-20	18	Wet soils, past harvest
Beaver-Triangle	7	CCR	18	Feller Buncher	None	10-25%	S	8	4.7 L/D	4-28	10	-
Beaver-Triangle	9	CCR	5	Feller Buncher	None	10-15%	SE	10	10 L/D	60, 90	10	-
Beaver-Triangle	4	CCR	42	Feller Buncher	None	0-20%	SE	10	4 L/D	2-14	15	-
Beaver-Triangle	5	CCR	10	Feller Buncher	None	10-15%	SE	15	3.5 L/D	12-28	17	Small unit, high density of skidtrails
Beaver-Triangle	6	CCR	9	Feller Buncher	None	15-25%	S	17	6.5 L/D	2-14	20	Small unit, dispersed

Project	Unit	Rx	Acres	Log System	Fuels Treatmt	Slope	Aspect	Bare Soil %	Forest Floor (cm)	CWD (t/a)	Soil Disturb %	Factors why >15%
												skid traffic
Beaver-Triangle	3	CCR	9	Feller Buncher portion	None	10-25%	S	0	5.5 L/D	12-31, 80	8	-
Dog Marquette	1 (Sale)	CCR	10	Tractor/ Cable	Rx Burn - Good	20-40%	S	20	1.3 L/D	0-65	22	Big trees to skid and remnant road prism
Beaver-Triangle	3	CCR	9	Cable portion	None	30-35%	SE	0	0	0	0	-
Brick Trout	3	CCR	11	Skyline	Rx Burn - Excellent	5-35%	W	13	0.8 L/D	0-5	0	-
Dog Marquette	2	CCR	12	Skyline	Rx Burn - Good	15-50%	S	13	2.8 L/D	0-9, 65	0	-
Beaver-Triangle	1 (Sale)	CCR	6	Skyline	None	45-60%	S	4	5 L/D	9, 60	0	-
Beaver-Triangle	8	CCR	18	Skyline	None	35-40%	SE	2	4.5 L/D	8,57	0	-
Dog Marquette	3	CCR	22	Skyline	Rx Burn - Fair	30-50%	SW	27	.9 L	2-26	2	-
Brick Trout	5	CCR	27	Skyline	Rx Burn - Good	10-50%	NW-NE	22	1 L/D	15-26	3	-
Brick Trout	6	CCR	60	Skyline	Rx Burn - Good	30-50%	N-NE	10	1.3 L	3-25	3	-
Beaver-Triangle	2	CCR	12	Skyline	Rx Burn (10% of unit)	30-50%	SE	6	6.3 L/D	6-20	6	-
Brick Trout	7	CCR	44	Skyline	Rx Burn - Good	0-40%	NW-NE	20	1.3 L/D	6-10	7	-
Brick Trout	2 (Sale)	CCR	26	Skyline/ Tractor	Rx Burn - Fair	25-40%	SE	24	0.6 D	3-4	2	-
Brick Trout	4	CCR	26	Skyline/ Tractor	Rx Burn - Poor	0-40%	N-NE	33	0	2.5	7	-

Project	Unit	Rx	Acres	Log System	Fuels Treatmt	Slope	Aspect	Bare Soil %	Forest Floor (cm)	CWD (t/a)	Soil Disturb %	Factors why >15%
Dog Marquette	4	CCR	44	Skyline/ Tractor	Rx Burn - Good	0-40%	SE	26	.9 L/D	1-5, 31	16	Hot burn concentrations, complex topo

Appendix 2. Background soil information for monitored timber sale units.

Table 1. Background soil information for each timber sale unit from Clearwater NF Landtype Mapping (USDA 1983).

Project	Sale unit	Landtype	geology	Dominant Landform	Depth	texture	Topsoil	soil classification
White White	8	31G20	weathered granitics and gneiss	Low Relief rolling hills	60+	sil/sl	ashcap (7-18")	Andic dystrochrepts, loamy-skeletal, mixed , frigid
White White	8	24A01	alluvium	Low Relief rolling hills	60+	sil/sicl	ashcap (7-23")	eutric glossoboralfs, medial/loamy, mixed, frigid
White White	8	24G20	weathered granitics and gneiss	Low Relief rolling hills	60+	sil/sl	ashcap (7-23")	Typic vitrandepts, medial/loamyu, mixed, frigid,
White White	6	24G20	weathered granitics and gneiss	Low Relief rolling hills	60+	sil/sl	ashcap (7-23")	Typic vitrandepts, medial/loamyu, mixed, frigid,
White White	6	22G00	deeply weathered granitics and gneiss	Low Relief rolling hills	60+	sil/sl	ashcap (8-28")	Typic vitrandepts, medial/loamyu, mixed, frigid,
White White	6	31G20	weathered granitics and gneiss	Low Relief rolling hills	60+	sil/sl	ashcap (7-18")	Andic dystrochrepts, loamy-skeletal, mixed , frigid
White White	6	24G20	weathered granitics and gneiss	Low Relief rolling hills	60+	sil/sl	ashcap (7-23")	Typic vitrandepts, medial/loamyu, mixed, frigid,
White White	5	24G20	weathered granitics and gneiss	Low Relief rolling hills	60+	sil/sl	ashcap (7-23")	Typic vitrandepts, medial/loamyu, mixed, frigid,
White White	5	24A01	alluvium	Low Relief rolling hills	60+	sil/sicl	ashcap (7-23")	eutric glossoboralfs, medial/loamy, mixed, frigid
White White	4	24G20	weathered granitics and gneiss	Low Relief rolling hills	60+	sil/sl	ashcap (7-23")	Typic vitrandepts, medial/loamyu, mixed, frigid,

Project	Sale unit	Landtype	geology	Dominant Landform	Depth	texture	Topsoil	soil classification
White White	4	24A01	alluvium	Low Relief rolling hills	60+	sil/sicl	ashcap (7-23")	eutric glossoboralfs, medial/loamy, mixed, frigid
White White	7	24A01	alluvium	Low Relief rolling hills	60+	sil/sicl	ashcap (7-23")	eutric glossoboralfs, medial/loamy, mixed, frigid
White White	7	24A01	alluvium	Low Relief rolling hills	60+	sil/sicl	ashcap (7-23")	eutric glossoboralfs, medial/loamy, mixed, frigid
White White	9	24A01	alluvium	Low Relief rolling hills	60+	sil/sicl	ashcap (7-23")	eutric glossoboralfs, medial/loamy, mixed, frigid
White White	-	24G10	weathered granitics and gneiss	Low Relief rolling hills	60+	sil/sl	ashcap (10-24")	Typic vitrandepts, medial/loamy, mixed, frigid,
White White	13	24A01	alluvium	Low Relief rolling hills	60+	sil/sicl	ashcap (7-23")	eutric glossoboralfs, medial/loamy, mixed, frigid
White White	23	22G00	deeply weathered granitics and gneiss	Low Relief rolling hills	60+	sil/sl	ashcap (8-28")	Typic vitrandepts, medial/loamyu, mixed, frigid,
Beaver Triangle	4	33U66	weakly weatherd, undiff bedrock	alpine ice cap	60+	sil/sl	ashcap (7-14)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	4	38U80	weakly weatherd, undiff bedrock	alpine ice cap	10-40	sil/sl	ashcap (6-17)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	4	33U66	weakly weatherd, undiff bedrock	alpine ice cap	60+	sil/sl	ashcap (7-14)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	4	38U80	weakly weatherd, undiff bedrock	alpine ice cap	10-40	sil/sl	ashcap (6-17)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	9	38U80	weakly weatherd, undiff bedrock	alpine ice cap	10-40	sil/sl	ashcap (6-17)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	5	33U66	weakly weatherd, undiff bedrock	alpine ice cap	60+	sil/sl	ashcap (7-14)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	5	38U80	weakly weatherd, undiff bedrock	alpine ice cap	10-40	sil/sl	ashcap (6-17)	Andic cryochrepts, loamy-skeletal, mixed

Project	Sale unit	Landtype	geology	Dominant Landform	Depth	texture	Topsoil	soil classification
Beaver Triangle	3	38U80	weakly weatherd, undiff bedrock	Frost churned ridges	10-40	sil/sl	ashcap (6-17)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	3	32U80	weakly weatherd, undiff bedrock	Frost churned ridges	30-48	sil/sl	ashcap (6-10)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	6	33U80	weakly weatherd, undiff bedrock	Frost churned ridges	40-48	sil/sl	ashcap (6-17)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	1	32L91	glacial till	Frost churned ridges	60+	sil/sl	ashcap (6-12)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	1	38U80	weakly weatherd, undiff bedrock	Frost churned ridges	10-40	sil/sl	ashcap (6-17)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	2	32L91	glacial till	Frost churned ridges	60+	sil/sl	ashcap (6-12)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	7	33U80	weakly weatherd, undiff bedrock	Frost churned ridges	40-48	sil/sl	ashcap (6-17)	Andic cryochrepts, loamy-skeletal, mixed
Beaver Triangle	8	36U92	Belt/granitics/till	Frost churned ridges	60+	sil/sl	ashcap (7-17)	Andic cryochrepts, loamy-skeletal, mixed
Brick Trout	2	22S00	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-26)	Eutric glossoboralfs, medial/loamy, mixed, frigid
Brick Trout	2	24S45	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-20)	
Brick Trout	3	22S10		Low Relief rolling hills				
Brick Trout	3	24S10	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-22)	Eutric glossoboralfs, fine-loamy, mixed, frigid
Brick Trout	4	22S00	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-26)	eutric glossoboralfs, medial/loamy, mixed, frigid
Brick Trout	4	24S10	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-22)	Eutric glossoboralfs, fine-loamy, mixed, frigid
Brick Trout	5	22S00	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-26)	Eutric Glossoboralfs, medial/loamy, mixed, frigid
Brick Trout	5	22S10		Low Relief rolling hills				

Project	Sale unit	Landtype	geology	Dominant Landform	Depth	texture	Topsoil	soil classification
Brick Trout	5	31S10	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-18)	Andic Dystrochrepts, loamy-skeletal, mixed frigid
Brick Trout	6	22A01	alluvium	Low Relief rolling hills	60+	sil/sl	ashcap (6-24)	Eutric glossoboralfs, fine-loamy, mixed, frigid
Brick Trout	6	24S10	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-22)	Eutric glossoboralfs, fine-loamy, mixed, frigid
Brick Trout	7	24S10	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-22)	Eutric glossoboralfs, fine-loamy, mixed, frigid
Brick Trout	7	24S20	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-20)	Andic Dystrochrepts, coarse-loamy, mixed frigid
Brick Trout	7	31S20	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-18)	Andic Dystrochrepts, loamy-skeletal, mixed frigid
Dog Marquette	1	24S45	micaceous schists and gneisses	Low Relief rolling hills	60+	sil/sl	ashcap (7-20)	
Dog Marquette	2	61S20	micaceous schists and gneisses	Breaklands	60+	sil/sl	ashcap (7-18)	Andic Dystrochrepts, loamy-skeletal, mixed frigid
Dog Marquette	3	61S20	micaceous schists and gneisses	Breaklands	60+	sil/sl	ashcap (7-18)	Andic Dystrochrepts, loamy-skeletal, mixed frigid
Dog Marquette	3	24S45	micaceous schists and gneisses	Breaklands	60+	sil/sl	ashcap (7-20)	
Dog Marquette	4	24S45	micaceous schists and gneisses	Breaklands	60+	sil/sl	ashcap (7-20)	
Dog Marquette	4	24S20	micaceous schists and gneisses	Breaklands	60+	sil/sl	ashcap (7-20)	Andic Dystrochrepts, coarse-loamy, mixed frigid
Dog Marquette	4	61S20	micaceous schists and gneisses	Breaklands	60+	sil/sl	ashcap (7-18)	Andic Dystrochrepts, loamy-skeletal, mixed frigid
Abe's Animals		22G00	deeply weathered granitics and gneiss	Low Relief rolling hills	60+	sil/sl	ashcap (8-28")	Typic Vitrandepts, medial/loamyu, mixed,

Project	Sale unit	Landtype	geology	Dominant Landform	Depth	texture	Topsoil	soil classification
								frigid,
Abe's Animals		22A00	alluvium deposits from palouse loess	Low Relief rolling hills	60+	sil	ashcap	Andeptic Paleboralfs
Abe's Animals		24G20	weathered granitics and gneiss	Moderate Relief uplands	60+	sil/sl	ashcap (7-23")	Typic Vitrandepts, medial/loamy, mixed, frigid,
Abe's Animals		22A01	alluvium deposits from palouse loess	Low Relief rolling hills	60+	sil/sicl	ashcap (6-24)	Eutric Glossoboralfs, medial/fine loamy, mixed, frigid